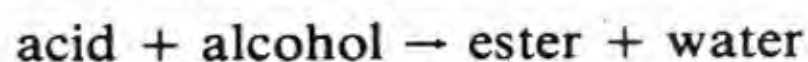


# Activity 9-6

## Reactions of Hydrocarbon Derivatives I

### Esterification

Esters are formed by the reaction between organic acids and alcohols. In general:

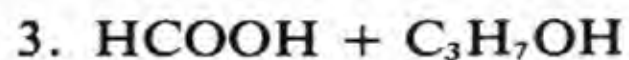


1. What is the general formula for an ester?

Write equations for the following esterification reactions using structural formulas. Write the IUPAC name for the acid, alcohol, and ester for each example.



Names:



Names:



Names:



5. All bonds in ester molecules are \_\_\_\_\_ (covalent/ionic).

6. The characteristic odor for many fruits and flowers is due to the presence of esters in these plants. Find the names of three esters and, for each, name a plant that has the corresponding characteristic odor. Write the names in the table on page 316.

Ester	Plant
ethyl acetate	apples
iso-amyl acetate	bananas
methyl salicylate	wintergreen

Note: Other esters and corresponding odors may be given.

7. Concentrated sulfuric acid is often used as a catalyst in esterification reactions. How does this increase the yield? \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

## Fermentation

8. In the fermentation process, enzymes produced by living organisms act as \_\_\_\_\_. Carbohydrates are converted to \_\_\_\_\_ among other products. A common fermentation product is ethanol, whose molecular formula is \_\_\_\_\_. The six-carbon sugar glucose, whose formula is \_\_\_\_\_, becomes reduced to \_\_\_\_\_ and oxidized to \_\_\_\_\_ by the action of the enzyme zymase, which is found in yeast.
9. Complete and balance this equation for the fermentation of glucose.  

$$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{_____}$$
10. Complete and balance this equation for the complete combustion of ethanol.  

$$\text{C}_2\text{H}_5\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{_____}$$

## Saponification

11. The hydrolysis of fats by bases is called \_\_\_\_\_. Common soap is produced by a saponification reaction. Glyceryl stearate  $(\text{C}_{17}\text{H}_{35}\text{COO})_3\text{C}_3\text{H}_5$  is the component of animal \_\_\_\_\_ that reacts with hot, concentrated lye (NaOH). The products are \_\_\_\_\_,  $\text{NaC}_{17}\text{H}_{35}\text{COO}$  (common soap), and \_\_\_\_\_,  $\text{C}_3\text{H}_5(\text{OH})_3$  (glycerine).
12. Convert the following equation for saponification to structural formulas.  

$$(\text{C}_{17}\text{H}_{35}\text{COO})_3\text{C}_3\text{H}_5 + 3\text{NaOH} \rightarrow \text{C}_3\text{H}_5(\text{OH})_3 + 3\text{C}_{17}\text{H}_{35}\text{COONa}$$
- +
13. Calcium stearate is the major component of the scum formed when soap is used in hard water. Complete this equation to show this reaction between  $\text{Ca}^{2+}(\text{aq})$  and sodium stearate.  

$$\text{Ca}^{2+}(\text{aq}) + \text{C}_{17}\text{H}_{35}\text{COO}^{-}(\text{aq}) \rightleftharpoons \text{_____}(\text{s})$$

# Activity 9-7

## Reactions of Hydrocarbon Derivatives II

### Combustion

Like hydrocarbons (see Activity 9-3), alcohols undergo simple combustion (burning) in excess oxygen, producing carbon dioxide and water.

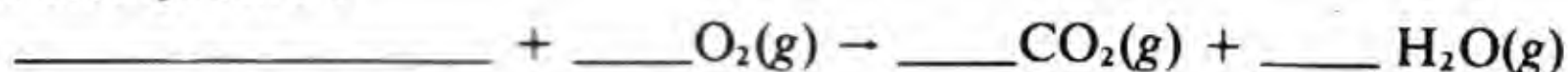
1. Write a balanced equation for the combustion of  $\text{CH}_3\text{OH}$  in excess oxygen.

\_\_\_\_\_

2. Write a balanced equation for the combustion of  $\text{C}_3\text{H}_7\text{OH}$  in excess oxygen.

\_\_\_\_\_

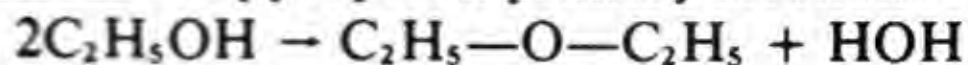
3. Diethyl ether vapor reacts explosively with oxygen. Complete and balance the equation for the burning of diethyl ether.



4. What total volume, at STP, of  $\text{CO}_2(\text{g})$  and  $\text{H}_2\text{O}(\text{g})$  will be produced when 0.150 mole diethyl ether burns in excess oxygen? Show a labeled setup, do arithmetic on scrap paper, and then write your answer below your setup.

### Dehydration

5. The functional group of an ether is \_\_\_\_\_. Ethers can be produced by the \_\_\_\_\_ of appropriate primary alcohols:



Concentrated \_\_\_\_\_ acid is often used as a dehydrating agent.

### Polymerization by condensation

6. a. What is a polymer? (See Activity 9-3.) \_\_\_\_\_

\_\_\_\_\_

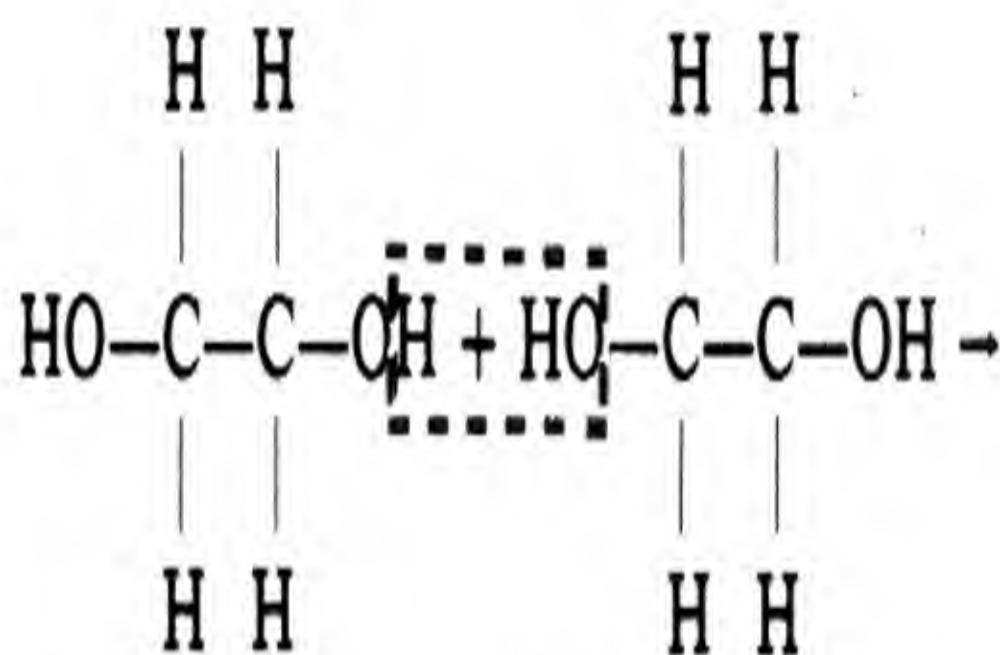
\_\_\_\_\_

- b. What is a copolymer? \_\_\_\_\_

\_\_\_\_\_



7. A condensation polymer can be produced by the bonding of monomers in a \_\_\_\_\_ reaction. The polymer becomes a giant molecule usually in the form of a long \_\_\_\_\_. The small molecule, \_\_\_\_\_, splits out during successive stages of dehydration. The monomers that serve as starting materials must contain two \_\_\_\_\_ groups, one at each end of the chain to permit further reaction. Complete this equation to show dimer formation.

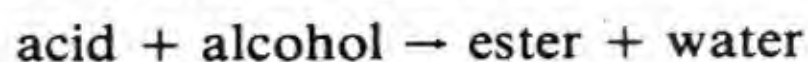


# Activity 9-6

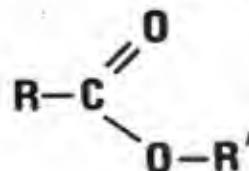
## Reactions of Hydrocarbon Derivatives I

### Esterification

Esters are formed by the reaction between organic acids and alcohols. In general:

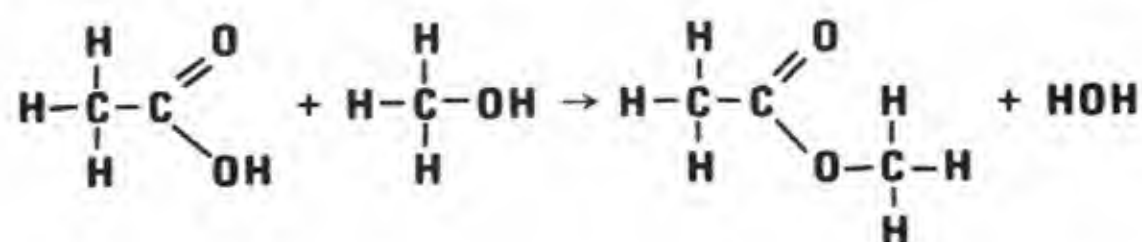


1. What is the general formula for an ester?



Write equations for the following esterification reactions using structural formulas. Write the IUPAC name for the acid, alcohol, and ester for each example.

2.  $\text{CH}_3\text{COOH} + \text{CH}_3\text{OH}$



Names:

ethanoic acid

methanol

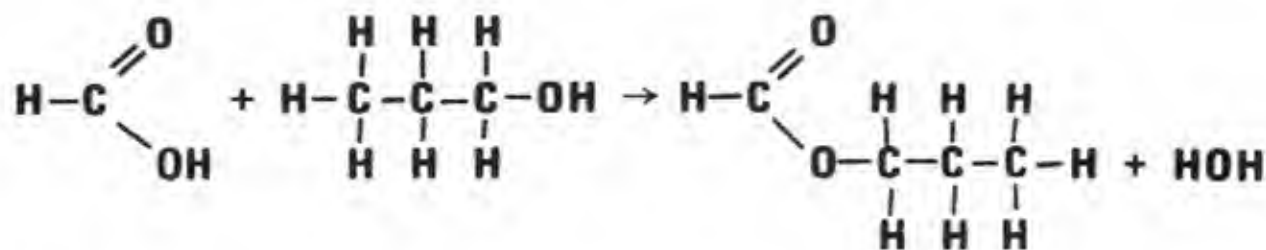
methyl ethanoate or methyl acetate

+

→

water

3.  $\text{HCOOH} + \text{C}_3\text{H}_7\text{OH}$



Names:

methanoic acid

1-propanol

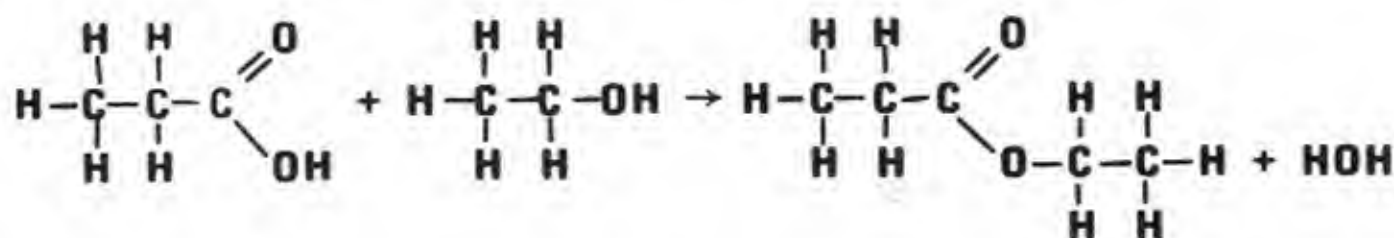
propyl methanoate

+

→

water

4.  $\text{C}_2\text{H}_5\text{COOH} + \text{C}_2\text{H}_5\text{OH}$



Names:

propanoic acid

ethanol

ethyl propanoate

+

→

water

5. All bonds in ester molecules are covalent (covalent/ionic).

6. The characteristic odor for many fruits and flowers is due to the presence of esters in these plants. Find the names of three esters and, for each, name a plant that has the corresponding characteristic odor. Write the names in the table on page 316.

Ester	Plant
ethyl acetate	apples
iso-amyl acetate	bananas
methyl salicylate	wintergreen

Note: Other esters and corresponding odors may be given.

7. Concentrated sulfuric acid is often used as a catalyst in esterification reactions. How does this increase the yield? Concentrated  $H_2SO_4$  dehydrates the organic mixture and shifts the equilibrium to favor the products by absorbing  $H_2O$ .

## Fermentation

8. In the fermentation process, enzymes produced by living organisms act as catalysts. Carbohydrates are converted to alcohol among other products. A common fermentation product is ethanol, whose molecular formula is  $C_2H_5OH$ . The six-carbon sugar glucose, whose formula is  $C_6H_{12}O_6$ , becomes reduced to  $C_2H_5OH$  and oxidized to  $CO_2$  by the action of the enzyme zymase, which is found in yeast.
9. Complete and balance this equation for the fermentation of glucose.  
1  $C_6H_{12}O_6 \rightarrow$  2  $C_2H_5OH$  + 2  $CO_2$
10. Complete and balance this equation for the complete combustion of ethanol.  
1  $C_2H_5OH$  + 3  $O_2 \rightarrow$  2  $CO_2$  + 3  $H_2O$

## Saponification

11. The hydrolysis of fats by bases is called saponification. Common soap is produced by a saponification reaction. Glyceryl stearate  $(C_{17}H_{35}COO)_3C_3H_5$  is the component of animal fat that reacts with hot, concentrated lye (NaOH). The products are sodium stearate,  $NaC_{17}H_{35}COO$  (common soap), and glycerol,  $C_3H_5(OH)_3$  (glycerine).
12. Convert the following equation for saponification to structural formulas.  
 $(C_{17}H_{35}COO)_3C_3H_5 + 3NaOH \rightarrow C_3H_5(OH)_3 + 3C_{17}H_{35}COONa$
- $$\begin{array}{c}
 H \\
 | \\
 H-C-O-C(=O)-C_{17}H_{35} \\
 | \\
 H-C-O-C(=O)-C_{17}H_{35} \\
 | \\
 H-C-O-C(=O)-C_{17}H_{35} \\
 | \\
 H
 \end{array}
 + 3NaOH \rightarrow
 \begin{array}{c}
 H \\
 | \\
 H-C-OH \\
 | \\
 H-C-OH \\
 | \\
 H-C-OH \\
 | \\
 H
 \end{array}
 + 3 \left( C_{17}H_{35}-C(=O)-O^- \right) + 3Na^+$$
13. Calcium stearate is the major component of the scum formed when soap is used in hard water. Complete this equation to show this reaction between  $Ca^{2+}(aq)$  and sodium stearate.  
1  $Ca^{2+}(aq)$  + 2  $C_{17}H_{35}COO^-(aq) \rightleftharpoons$   $Ca(C_{17}H_{35}COO)_2$  (s)



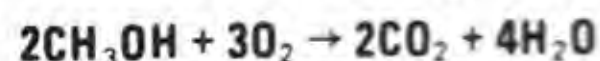
# Activity 9-7

## Reactions of Hydrocarbon Derivatives II

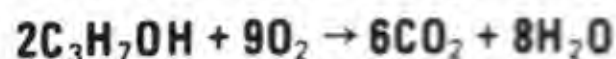
### Combustion

Like hydrocarbons (see Activity 9-3), alcohols undergo simple combustion (burning) in excess oxygen, producing carbon dioxide and water.

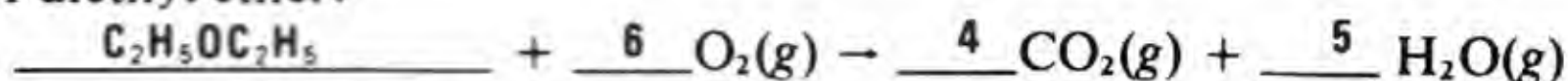
1. Write a balanced equation for the combustion of  $\text{CH}_3\text{OH}$  in excess oxygen.



2. Write a balanced equation for the combustion of  $\text{C}_3\text{H}_7\text{OH}$  in excess oxygen.



3. Diethyl ether vapor reacts explosively with oxygen. Complete and balance the equation for the burning of diethyl ether.



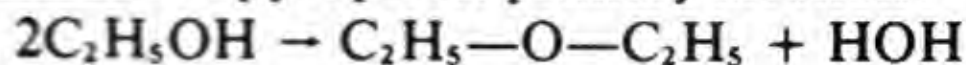
4. What total volume, at STP, of  $\text{CO}_2(\text{g})$  and  $\text{H}_2\text{O}(\text{g})$  will be produced when 0.150 mole diethyl ether burns in excess oxygen? Show a labeled setup, do arithmetic on scrap paper, and then write your answer below your setup.

$$0.150 \text{ mol C}_2\text{H}_5\text{OC}_2\text{H}_5 \times \frac{9 \text{ mol gas}}{1 \text{ mol ether}} \times \frac{22.4 \text{ L}}{1 \text{ mol gas}} = 30.24 \text{ L}$$

30.2 L total volume of gas ( $\text{CO}_2 + \text{H}_2\text{O}$ )

### Dehydration

5. The functional group of an ether is  $\text{R}-\text{O}-\text{R}'$ . Ethers can be produced by the dehydration of appropriate primary alcohols:



Concentrated sulfuric acid is often used as a dehydrating agent.

### Polymerization by condensation

6. a. What is a polymer? (See Activity 9-3.) a compound made up of a large molecule consisting of smaller, repeating units called monomers
- 

- b. What is a copolymer? a polymer made from two or more different monomers
-

7. A condensation polymer can be produced by the bonding of monomers in a condensation polymerization reaction. The polymer becomes a giant molecule usually in the form of a long chain. The small molecule, water, splits out during successive stages of dehydration. The monomers that serve as starting materials must contain two OH or functional groups, one at each end of the chain to permit further reaction. Complete this equation to show dimer formation.

